NETWORKING: SOME IMPRESSIONS FROM CIMMYT

Donald L. Winkelmann

Director General, International Center for the Improvement of Maize and Wheat (CIMMYT), Mexico D.F., Mexico

Introduction

Networks are an ever more prominent theme in the implementation and management of agricultural research. One evidence of this burgeoning interest is the number of papers and meetings that deal with the subject. Quoting titles, of course, is one of the traditional ways to measure interest in any topic researchers write and a good way to keep score is to count up what they are writing about.

What is the essence of the idea? What are networks all about? Seen simply, a network is a collection of individuals or institutions with common interests, and the associated mechanisms through which information about those interests are communicated.

And our history, not just as researchers but as a species, gives ample evidence of the benefits of communication among those pursuing like interests. Many of the adages that shape our behavior emerge from the awareness that the exchange of ideas is a powerful force in shaping progress. We are told we should not "rediscover the wheel", and that "two heads are better than one."

What distinguishes our current interest in the active pursuit of this form is the belief that it can bring substantially greater output from our research systems and the belief that the commonality of our problems will override the selfishness of particular interest.

I propose to examine some of these ideas in the course of this discussion. I will briefly review the initiation of networks in agricultural research in this century, will talk about some of the essences of networks, as winkled out by avid students of the form, with some examples of each, will then describe some of CIMMYT's experiences and their consequences, and will talk about possible formats for the future. While you will clearly sense my support for the underlying principles, I hope that you will also detect a certain caution in viewing what the format itself can deliver. To preview that caution, there are several conditions that must hold if networks are to achieve their aims. We must not let exuberance and wishes overwhelm common sense as we view opportunities.

History

The history of informal networks for agricultural research is probably as old as the first attempts by early agriculturists to learn from one another, as each sought to wrest more from their collaboration with Nature.

We see that kind of networking throughout agriculture today as, around the world, farmers learn from each other's experiences.

Plucknett and Smith (1984) report that during the colonial period the European powers each established a series of research stations that shared, but only among compatriots, information on the export crops then under investigation. Early 20th century examples (Plucknett and Smith) include U.S. efforts coordinated by USDA and concentrated on maize and wheat. In the 1920s, there was a regional maize network in the U.S. Mid-West that encouraged the sharing of ideas on the development of hybrids so as to reduce duplications and to ensure that results were easily available to those pursuing this goal. At about the same time, regional networks were formed to share results among wheat breeders, especially winter wheat breeders in the northern Great Plains and in the North Central region.

A first major move towards internationalizing the network concept occurred in the early 1930s as a consequence of the outbreak of a stem rust epidemic, race 15B, in the U.S. Impetus for this effort came from USDA, obviously concerned about the devastating impact of the rust on production, but with willing support from collaborators in other countries as each realized that the problem might have hemispheric consequences. The collaborators -Argentina, Canada, Chile, Colombia, Ecuador, Mexico, and the U.S. -framed a nursery designed to identify sources of resistance to race 15B. The effort was successful in its quest. That success called the attention of others to the advantage of such collaboration so that, in time, more than 100 countries were participating in wheat networks.

Shortly after the stem rust efforts, in large measure motivated by the Office of Special Studies in Mexico -a joint project sponsored by the Government of Mexico and the Rockefeller Foundation -another international network was initiated in Central America, PCCMCA. In its earliest days this network concentrated on maize and had 20 to 30 associates, largely from Mexico and Central America. Over time, the range of crops expanded, the geographic coverage as well, and today the associates number in the hundreds. A primary manifestation of PCCMCA is its annual meeting, where research results are reported in structured sessions. While there is a limited sharing of germplasm among participants, there is ample exchange of ideas and findings on an informal basis. The annual meeting, to be held in 1987 in Guatemala, is heavily attended by researchers from Central America, the Caribbean, and tropical South America.

Also in the 1950s, in India, different kinds of networks were being formed among Indian scientists. These became the All-India Coordinated Crop Improvement Programs. The first of these networks were for maize, millet, and sorghum; they were soon extended to other crops, including rice and wheat. Again, each of these networks features an annual meeting, where results are reported, as well as the exchange, testing, and release of germplasm. Beyond this, however, the networks involved a considerable degree of coordination through the Indian agricultural research system.

By now networks in various forms and guises are a common feature of the agricultural research landscape. Just to give a modest sense of their application, IDRC reports that it has been involved in over 100 networks (Ker), USAID/SPAAR lists over 40 networks related to sub-Saharan Africa (SPAR), FAO reports that there are more than 100 international agricultural research networks (FAO). These are but a sample of the executions in place.

Characteristics of Networks

Most observers point to efficiency in resource use as a primary advantage of networks. In their minds, the source of this efficiency lies in the avoidance of duplication, in the attainment of critical mass, and in the exchange of ideas which, in turn, stimulate new perceptions in others. Beyond this, for some kinds of networks, there are efficiency gains because workers can concentrate on specific or individual problems rather than being required to disperse energies across a range of problems, a variant of the critical mass argument. A further significant advantage of networks is said to be that they encourage and develop self-reliance and the capacity to perform among those who participate. Many make this point in talking about networks.

In reviewing these advantages. one is disposed to endorse the arguments based on concentration and critical mass and on the exchange of ideas, but to ask about the cost of encouraging self-reliance through the network as contrasted with other options. With respect to duplication, it can raise the probability of attaining a given outcome, hence is clearly not all bad. It should also be noted that from the perspective of donors, networks can be an efficient vehicle for supplementing national support to research.

And there are disadvantages as well. In large measure these emerge from the complexity of managing networks. With many participants of uneven experience and with differing levels of commitment. it is evident that coordination and direction must be a daunting task. As well, because of the cost associated with bringing participants together, networks can be costly undertakings.

Many forms of networks are emerging. In order to aid discussion and thinking, USAID/SPAAR, a group focussed on Sub-Saharan Africa, have identified three major collections of networks. The first aims at facilitating information exchange. The second does that and adds meetings in which professionals exchange ideas directly, usually on themes jointly identified. The third involves the second and adds joint priority setting, planning, implementing, and monitoring of defined undertakings, probably with some division and assignment of important tasks. Each step implies a greater commitment of national resources, a greater reliance on the efforts of the network and, I would add, greater complexity in coordination and higher costs.

In assessing the potential of networks, it is commonly said that they provide flexibility. It is also said they function best when based on the self-interest of participants which, in turn, rests on the conviction that they offer the efficient attainment of high-priority goals. It is also said that self-determination is an important condition in achieving flexibility and efficiency. The flexibility of the form is evident through examples of the various choices that are made in shaping networks. First, there is a general agreement that a network's structure should be a function of its problem or goals. For example, one would expect a different framework if the idea is to distribute, select, and report on the performance of varieties (some CIMMYT networks), or to work on particular germplasm needs of a specific region (as with PRECODEPA, a potato network in Central America), or to engage in on-farm research (as with a training network in Central America), or to adapt technologies developed elsewhere. Network purposes are as broad as pasture improvement (Lazier) and as narrow as fertilizer applications for rice (Greenland, Craswell, and Dagg). Networks are exclusive - requiring a certain test of competence or commitment before entry is permitted - or inclusive - where a manifestation of interest is sufficient to gain entrance. And beyond this, networks are phased, proceeding from one step to another in a planned way as time passes and experience accumulates, are designed with sunset clauses, or are indefinite in their anticipated life.

Most speak of the need to have participants involved in the decision making of the network. This is especially the case where an IARC or regional center is involved. Indeed, virtually all recent comment on networks make this point. It is held that some form of self-determination assures that methods and style are more consistent with the capacities of national programs and that these can be adjusted to their accumulating experience. Beyond that, there is said to be more assurance that the problems of the network will be the high-priority problems of the national programs. Otherwise, and to the extent that the participants are committing resources to the network, there is the risk that those resources will be warped away from national priorities.

There have been complaints in this regard about the nursery networks of the IARCs. Some claim that the nurseries, while requiring NARS resources, have not always conformed with their needs. In these cases, critics claim, the networks are more the instruments of the IARCs than of the participating national problems.

Certainly, priority setting is an important theme in establishing a network, especially to the extent that NARS resource commitments are large. In reflecting on the issue, three points appear to be relevant. First, of course, what is the extent of the commitment of NARS resources? And to what extent does the existence of the one network preclude the development of other networks? Beyond this, which is the participant whose priorities must be considered? Is it the national program, where there is a presumption that national priorities will be heavily weighted? Is it the individual researcher, in which case the priorities frequently will combine elements of national concerns with elements of the personal concerns of the researcher. National and personal concerns can be quite congruent but, where they diverge, there is more chance of the warping referred to earlier. Not to put too fine a point on it, it has been observed that association with some networks brings considerable individual advantage in the way of travel, training, and scholarships, as well as the aggrandizement of reputations, and that at times favored activities are not obviously related to national goals. The point warrants careful consideration by research leaders: self-determination for whose ends, in what time frame, and how monitored?

Finally, in reviewing the general experience of networks, I have chosen six recent pieces on the theme, all published since 1984 and all emerging from knowledgeable and committed commentators on agricultural research. An examination of lists of success elements is clear testimony that, to attain their goals, networks require much more than just the banner.

Each of the six articles lists success elements. The shortest list contained six, the longest nine. Some 20 different elements are noted. (See appendix). Most commonly cited are: a clearly defined problem or goal, strong self-interest in an important problem, strong and effective leadership, resource commitments on the part of participants, access to outside funding, and an effective advisory group. With multiple mention, but less frequent, are that participants should have sufficient training and skill to make contributions and that there should be specific allowance for free exchange of germplasm and ideas.

Much attention, unhappily, was given to the leadership/coordinating requirements, with adjectives that would suggest difficulty in encountering the necessary blend of attributes. I say "unhappily" because robustness and a dependence on uniqueness do not frequently go hand in hand. One wonders if somehow the apparatus might not be redesigned so as to rest less heavily on the attributes of singular individuals. Perhaps emphasis on the advisory groups, on strong self-interest, and on clearly defined problems can substitute, to some degree, so that more ordinary mortals might qualify for the role.

Most of the articles ascribed a role in networks to the IARCs. According to some, that role, frequently in coordination, is based on IARC capacity to attract funding, on the scientific competence they exhibit, on the trust that national programs usually put in their evenhandedness, and on their connection to up-stream research. The IARCs also have their critics in this role: for some, the IARCs too frequently see the network as an instrument of the center; the personalities of the would-be IARC coordinators sometimes hold the hint of arrogance: and for some, since one of the advantages of the network form is in its promise of developing its members, especially those who coordinate, why not reserve that potential development to NARS staff?

What seems more central to the IARC role is an underlying harmony of interest. To the extent that IARCs accent the development of national program capacities, shaping decisions to that end, and to the extent that more effective communication makes for more effective research, there is a clear coincidence of interest on networks among IARCs and the NARS. And that interest, the fostering of communication and competence, would seem to be the point on which IARC participation in networks should properly rest.

In reflecting on desirable degrees of integration, think again of the earlier description of the three classes of networks. The first implies little integration, just a sharing of ideas, methods, results, and germplasm. The second implies more integration as it involves scheduled meetings and the richer exchange that such meetings permit. Each country still sets its own priorities, but each must commit some resources to the scheduled meetings. As well, this format might include sharing of information on priorities and joint monitoring tours as a part of further enriching the exchange of information. The tours can assure that priorities are being pursued, facilitate the comparison of product, foster the energizing forces of competition among programs, and reassure one and all about the extent to which commitments to exchange are being honored. The third class of network implies the highest degree of integration. Here the commitment is to joint priority fixing, planning, implementation, and monitoring. Presumably, as well, there is a partition of effort; otherwise, why joint priority fixing, planning, and implementation? After all, each knows his own priorities and, unless otherwise persuaded, will assign resources to conform with them. That assignment would only be altered where there is an assurance that another agency would provide the higher priority products, and this implies a division of labor, a partition of tasks.

What are the factors that influence the degree of integration of a network? What determines the potential advantages and disadvantages from each level of commitment?

Most obviously, the availability of critical mass in research resources influences the advantage from integration. In this context notice that, even without the critical mass to handle a broadly defined problem, e.g., maize improvement in its every important aspect, a program might still have sufficient resources to handle one set of problems, e.g., husk cover and downy mildew. With others in a similar circumstance, there is apparent advantage in strong integration so that problems can be partitioned and allocated among the participants.

Critical mass for a given country is closely related to its homogeneity. The more homogeneous a country's agriculture, the more likely it is to have a critical mass of resources for its priority research themes. And, in general, the less abundant the research resources relative to the various critical masses needed, the more advantageous is fuller integration in networks.

Problem definition, which is to say the purpose of the network, influences the potential advantage of integration. The more broadly defined the problem, other things equal, the more likely are advantages from joint priority fixing and planning. For example, if the network relates to pastures, then many more decisions about research resource allocations must be made than if the problem is wheat for aluminum soils. Again, it is evident that the availability of a critical mass is closely related to the definition of the problem. It can be argued that the narrower the problem is defined, the less the need for joint priority fixing and planning. After all, association with the network is itself an evidence of the priority of the national program. It follows, of course, that there must have been some previous joint planning in order to have singled out the critical problem around which the network was formed.

And what of the potential disadvantages? Under what circumstances might a research director choose a lesser over a fuller integration with a network? Other things equal, some research directors might be reluctant to surrender to the researchers of another country the responsibility for the significant problems of an important crop, unless there are markets through which the products of research could be bought and sold (as with hybrid maize seed, for example). I should add that, when such markets exist, there is reluctance to share fully the results of research; again the case of hybrid maize is the classic example.

Some will present another disadvantage, arguing that, other things equal, they would rather not see their resources and those of others committed to a single line of research for fear that it might not be a preferred approach, the idea that "one should not put all eggs in one basket", a comment on risk management.

Third, and again other things equal, some will argue that, if critical mass conditions are met, there is a higher probability of progress when programs compete actively among themselves, but sharing materials so that these can serve as the standard against which individual performance is judged. These are some of the potential disadvantages to networks, which include joint planning and partitioning of responsibilities. Research managers must balance these advantages and disadvantages. It does seem evident, though, that they would choose the simplest form which is consistent with their goals and their circumstances.

CIMMYT and Networks

Let me turn now to a review of CIMMYT's experiences in networks. Some 20 years ago CIMMYT began its working life already associated with networks. The earliest experiences date back to the 1950s, with the USDA-sponsored effort to find resistance to race 15b of stem rust. CIMMYT's predecessor organization participated in this search. Following by little was the Rockefeller Foundation and Oficina de Estudios Especiales involvement in the development of the PCCMCA. And by the early 1960s Norman Borlaug and his colleagues were themselves sponsoring networks aimed at testing and delivering spring bread wheats to many of the developing world's wheat programs.

Today, CIMMYT is involved in several kinds of networks. These will be discussed under the following headings: nurseries, regional programs, special topics, and strategic science.

Nursery Networks

The first venture into international networks was the Inter-American Spring Wheat Yield Nursery, sent out to 15 collaborators in 1960. In 1962, after requests from numerous professionals, the nursery was expanded to include the Near East. In 1964 the network was again expanded and renamed the International Spring Bread Wheat Yield Nursery (ISWYN), the title that it still carries. Through the years variants of that nursery were added - for durums, for triticales, for barley. As well, other kinds of nurseries were established, e.g., disease monitoring and early generation nurseries. By 1979 CIMMYT managed 31 different nurseries operating across 100 countries, representing 1700 separate trials, and involving hundreds of participants. And in 1986, there were 3,000 trials from 47 nurseries in roughly 200 countries.

The current small grains nurseries specialize in yield, in screening, in early generation material, in crossing blocks, and in disease monitoring. As well there are nursery networks for special situations, e.g., septoria and aluminum soils. Each nursery contains different collections of germplasm and each, of course, serves a different purpose for those in the network. It has been said that these nurseries and the international testing which they support opened the modern era in plant breeding through their role in expanding the options available to plant breeders everywhere.

Meanwhile CIMMYT's maize program was also increasing its role with nurseries and international testing. By 1974 the maize program soon had expanded to three different classes of nurseries - progeny testing, experimental varieties, and elite materials. By 1981 the maize nursery network operated in 84 countries.

If one insists that a network must have, at the minimum, a common purpose, a two-way flow of information, and entail some commitment of resources by all participants, then most of CIMMYT's many undertakings with nurseries qualify as networks. Some wheat nurseries fail the test because they do not require that collaborators send information back to CIMMYT.

For both small grains and for maize, most of the nurseries now comprise material developed through CIMMYT. That material will frequently include in its immediate pedigree germplasm from other sources, but the final cross was probably done on one of the CIMMYT stations. That is not the case for the important yield trials in small grains and for the elite nurseries in maize. For these nurseries a significant portion of the materials included come directly from national program network members. For example, in a recent five-year period, some 42% of the entries in the international spring bread wheat yield nursery were from national program network members. And in the case of maize, in the 1985 elite variety trial, varieties established by national programs represented some 20% of the total. In both cases the trend is upwards.

Seen in terms of the earlier discussion, what can be said about the nursery networks? First, the purposes are well defined. For example, with the screening nurseries, promising new lines are provided to national programs which return to CIMMYT data that describe each line's performance under their conditions. All data are summarized, analyzed, and quickly returned to all participants for their use in further assessing the qualities of apparently promising materials.

Mechanisms involved are the nursery itself, the forms on which reporting is undertaken, and the publications carrying the results. As well there are the informal notes and observations that pass from one professional to another.

Some of the nursery networks are inclusive, e.g., the yield trials in small grains and the elite variety trials in maize, with participation open to all who apply, within the limits set by seed availability. Other networks are exclusive; e.g., nurseries of segregating materials are available only to mature national programs, and nurseries of experimental maize varieties are limited to those participants whose environments fit certain well-defined characteristics.

All of the networks are open-ended with respect to horizon. And as for type, and using the SPAAR classification, most are class one if seen on an annual basis but are class two if a longer time horizon is applied, e.g., for periodic workshops. None are class three, as the selection of materials for each nursery is not a joint activity, one shared by all participants in the nursery network. I would add that to achieve such participation would be enormously costly. Even so, all participants contribute to priority fixing, as each individually reflects the particular interests of his program to the CIMMYT coordinator of the nursery.

Nursery network operation is a complex task and a costly form of communication. Still, nurseries must be counted among the most effective of the agricultural research networks for their role in evaluating and delivering germplasm, in monitoring the development and spread of disease, in providing a vehicle for training, and in fostering a sense of community among breeders around the world. One commentator (Hanson) observed that "international nurseries are able to surmount ideological. religious, ethnic, and language differences".

Regional Programs

Each of CIMMYT's major progams operates regionally. Their staffs are largely made up of plant breeders, pathologists, agronomists, and economists. In every case their primary purpose is to foster the development of national research capacity. Their efforts concentrate on national capacity in crop improvement and husbandry for maize or wheat. A considerable portion of the work in husbandry involves both agronomists and economists, focusses on techniques for technology generation, and gives strong emphasis to on-farm research. Program staff participate in regional networks with national progam staff who share their concerns.

What results over time from the country-by-country efforts of the regional programs is an informal network. For example, plant breeders from the various countries and locations within the region come together every year or so in workshops focussed on issues in maize improvement. They frequently make field trips within the region with the purpose of seeing the breeding plots of professional peers in other national programs. Through all, they interact more frequently with the CIMMYT specialists who work alongside them, first in one country and then the next, carrying along and sharing the accumulating experience of each. These are class two models in the sense used by SPAAR.

For the specialist in breeding, a major element in the network is the nursery in its various roles. In several cases, the regional team joins professionals in the host country, e.g., Kenya, in the case of wheat in eastern and southern Africa, and Ecuador, in the case of the Andean Region, to organize special regional nurseries out of the more abundant material of the international nurseries.

For those concerned with husbandry, organized training sessions are the primary vehicle for communicating the message of the network. Such training is usually done in a single country but typically with a modest percentage of participants from nearby countries. For example, in a training program currently underway in Panama, some 10% of the participants come from neighboring countries. The standardizing element in this process, the element that ensures harmony from one country to the next, is the methodology on which the training is based. For some networks, e.g., in Eastern and Southern Africa, a second binding influence is the annual planning meetings held by research directors, or their representatives. These meetings decide the topics to be treated in the workshops and seminars, choosing themes of particular interest to the national programs of the region. CIMMYT's regional staff then coordinate those workshops. These, too, are class two networks in the SPAAR classification.

There is a growing amount of horizontal communication within these informal networks, as professionals from one country visit the plots or the field work in another and as meetings are moved from country to country so that, over time, professionals become more and more familiar with the work of their peers. In time, with the wider use of new electronic forms of communication, these linkages will be even stronger.

Still, many advocate an even more rapid integration and point in particular to broader participation in priority setting and planning. We see clear advantages in broad participation in those activities.

One example of this commitment is in the association now working on improving floury maize, an important class of maize in the Andean region. Several years ago CIMMYT deputed a breeder to the region, charged with working with the national program breeders. During the course of his stay in Ecuador, there were annual field trips and a continuous exchange of materials among national programs. By now, the CIMMYT staff member has returned to Mexico and to other tasks. The activity is on the way to being in the hands of the maize breeders from the region, with CIMMYT's future role in lending a hand in facilitating communication and in counseling on the evolution of the work. The national programs do not partition the problems (e.g., with each specializing on one or another of the major shortcomings in the available varieties), but rather each works on all of the high-priority problems of his program with all sharing materials as they advance.

Thus, at this time, CIMMYT's regional programs and the networks within which they function are of the second kind in the SPAAR definitions, featuring frequent meetings - most of them in the field but with workshops and seminars as well, widespread but not collective contributions to priority setting, and the free exchange of ideas, information, results, and germplasm. The networks are inclusive and indefinite in horizon.

Special Purpose Networks

CIMMYT staff also participate in several networks aimed at a particular problem and relying in significant measure on the scientific capacities of developed-country participants. Examples of these are, for maize, an aflatoxin network involving scientists from the basic science programs of developed-country universities, breeders and pathologists from developed and developing countries, and relevant CIMMYT staff. This is a newly established group, and there is every expectation that it will take sharper form over the near term. This association will probably involve an advisory counsel, joint planning, and the partition of selected tasks. The partitioning is favored by the general scarcity of the high science capacities, which is to say that the critical mass problem weighs heavily in shaping the network.

A second example, this time on the small grains side, is the network dealing with the problem of barley yellow dwarf virus. The membership is like that of the aflatoxin network. Again, while newly formed, the network is taking a rather different shape, as CIMMYT is serving as a hub through which ideas, findings, and funding are being channeled to the limited number of professionals concerned with the disease. In time, with more information and more interest in the disease, more options for research will become apparent and the advantages for more fully integrating the network will probably induce a movement towards the fully integrated form.

Strategic Networks

As I will describe them here, this class of network has not been much used by CIMMYT to date. There are, however, certain nursery networks which resemble this framework.

As national program experience develops, some work formerly done by CIMMYT falls naturally into their hands. For example, in an earlier day, when national programs had little experience with the semidwarf wheats, CIMMYT invested in applied and adaptative research featuring the agronomy necessary to generate appropriate technology. This work was done with national program colleagues within national programs and with CIMMYT staff heavily involved in the day-to-day activities. By now, with many national programs having themselves had substantial experience with these varieties, they are quite capable of undertaking that work on their own and do so. But new opportunities for research emerge from the widespread use of those varieties with the more intensive practices that usually accompany their use and from the increasing experience and capacity of national programs. One such opportunity relates to the question about what can be done to ensure sustainable yields under this more intensive cultivation.

One example occurs in the north of the Asian subcontinent, where substantial areas are under a wheat-rice rotation, with each producing far higher yields than even a decade ago. What are the implications for weed control, soil structure, salinity, and fertility over the course of the next decade? What should be done to maintain productivity?

To answer those questions will require more than standard agronomy. Researchers will have to pursue the answer through strategic research aimed at the underlying biological, chemical, and physical structures. Given that several countries share the problem, there would seem to be an opportunity to organize a network around just that theme, with joint priority fixing, a division of tasks, full sharing of results, field trips, and all of the remaining elements of class three networks.

In a sense, this model is but an extension of earlier CIMMYT experience. It is, for example, akin to the work on wheats for aluminum soils, a problem that motivated years of shuttle breeding by CIMMYT and colleagues in Brazil. Both have a specific goal that makes them limited-life networks. In the aluminum soils case, decision making was shared in that each team worked with the same material, and the choices of one shaped the options of the other. It differs in the sense that little priority fixing was needed in the first case; just forming the network was itself a measure of priorities and fixed the direction of the work. In the case of strategic research, however, there is a much greater requirement for priority fixing as well as a stronger need for specialists further removed from the experimental plots.

We believe that many options of this kind are on the horizon. Most will emerge as class three networks. We look forward to participating.

Conclusions

Efficiency in research is hugely enhanced by effective communication. Communication is greatly enhanced by networks. Networks, then, have a derived and considerable importance. Through them to give is not to lose, and to take is not to deprive.

While networks have a long history in research, formal networks are probably a product of this century. By now, hundreds of networks operate to the advantage of their participants. These take many forms, and which is chosen is related to the balancing of recognized advantages and disadvantages.

CIMMYT is involved with many networks of many forms. The accumulation of knowledge, experience, and interest will influence the shape of those networks over time, as participants strive to gain more from their associations. There will also be opportunities for new networks.

Networking requires the commitment of varying degrees of resources and differing obligations, depending on the degree of integration. Research managers choosing among network options must balance a series of benefits and costs associated with each. While doing this they will want to bear constantly in mind that to foster communications is to hasten gains and that their advantages in choosing the simplest form of communication is consistent with goals.

And, recounting the obvious, we must not expect too much from our networks. They can add many things -new energies, new ideas, new materials, new efficiencies -to global capacities. They can make our science better, but they will not, certainly not for long, replace that science. Means they are, and as means they must be judged.

Networks tie many of us together, national programs and CIMMYT. We look forward to reinforcing those connections through networks - old forms and new - and through the many other forms of cooperation, all so fruitful in the past and so promising for the future.

Appendix: Characteristics of networks considered important by several authors.

Characteristics *Authors** →	1	2	3	4	5	6
1. Clearly defined problem	X	X	X	X		X
2. Problem widely shared	X	X				
3. Strong self interest (important problem)	X	X	X	X	X	X
4. Participants commit resources to network	X	X		X		X
5. External funding	X	X	X			X
6. Capacity to make contributions	X	X				
7. Strong/effective coordinator	X	X	X	X	X	X
8. Sufficient new ideas and materials		X				
9. Participants contribute to management		X				
10. Regional scope			X			
11. Effective advisory group	X		X	X		
12. Scope for new ideas and free exchange	X		X	X		
13. Linkages upstream			X			
14. Clear theme *and* strategy				X		
15. Training and monitoring				X		
16. Common constraints					X	
17. Capacity to diffuse and to adapt					X	
18. Access to other networks					X	
19. Long horizons						X
20. Supplemental funding for NARS			X			

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THE IMPACT OF RESEARCH ON NATIONAL AGRICULTURAL DEVELOPMENT

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IFARD, International Federation of Agricultural Research Systems for Development
ISNAR, International Service for National Agricultural Research
CTA, Technical Center for Agricultural and Rural Cooperation
EMBRAPA, Empresa Brasileira de Pesquisa Agropecuária

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing, and operations.

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